Updated Status of Federally Listed ESUs of West Coast Salmon and Steelhead

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A.2.9. CENTRAL VALLEY SPRING-RUN CHINOOK SALMON

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A.2.9.1. Summary of Previous BRT Conclusions

The status of Central Valley spring-run chinook salmon was formally assessed during a coastwide status review (Myers et al. 1998). In June 1999, a BRT convened to update the status of this ESU by summarizing information and comments received since the 1997 status review and presenting BRT conclusions concerning four deferred chinook salmon ESUs (NMFS 1999).

Summary of major risk factors and status indicators

Threats to Central Valley (CV) spring-run chinook salmon fall into three broad categories: loss of most historic spawning habitat, degradation of remaining habitat, and genetic threats from the Feather River Hatchery spring-run chinook salmon program. Like most spring-run chinook salmon, CV spring-run chinook salmon require cool water while they mature in freshwater over the summer. In the Central Valley, summer water temperatures are suitable for chinook salmon only above 150-500 m elevation, and most such habitat in the CV is now upstream of impassable dams (Figure A.2.9.1). Only three wild populations of spring-run chinook salmon with consistent spawning runs (on Mill, Deer and Butte Creeks, tributaries to the Lower Sacramento River draining out of the southern Cascades) are extant. These populations reached quite low abundance levels during the late 1980s (5-year mean population sizes of 67-243 spawners), compared to a historic peak abundance of perhaps 700,000 spawners for the ESU (estimate of Fisher [1994], based on early gill-net fishery catches). The Upper Sacramento River supports a small spring-run population, but population status is poorly documented and the degree of hybridization with fall-run chinook salmon is unknown. Of the numerous populations once inhabiting Sierra Nevada streams, only the Feather River and Yuba River populations remain. The Feather River population is dependent on Feather River Hatchery (FRH) production, and may be hybridized with fall-run chinook salmon. Little is known about the status of the spring-run chinook salmon population on the Yuba River other than it appears to be small.

In addition to outright loss of habitat, CV spring-run chinook salmon must contend with the widespread habitat degradation and modification of their rearing and migration habitats in the natal stream, the Sacramento River, and the delta. The natal tributaries do not have large impassable dams like many Central Valley streams, but they do have many small hydropower dams and water diversions that, in some years, have greatly reduced or eliminated in-stream flows during spring-run migration periods. Problems in the migration corridor include unscreened or inadequately screened water diversions, predation by non-native species, and excessively high water temperatures.

The Feather and Yuba Rivers contain populations that are thought to be significantly influenced by the FRH spring-run chinook salmon stock. The FRH spring-run chinook salmon program releases its production far downstream of the hatchery[6], causing high rates of straying (CDFG 2001). There is concern that fall-run and spring-run chinook salmon have hybridized in the hatchery. The BRT viewed FRH as a major threat to the genetic integrity of the remaining wild spring-run chinook salmon populations.

[6] In 2003, CDFG plans to release half of its spring-run chinook production into the river, half into San Pablo Bay.

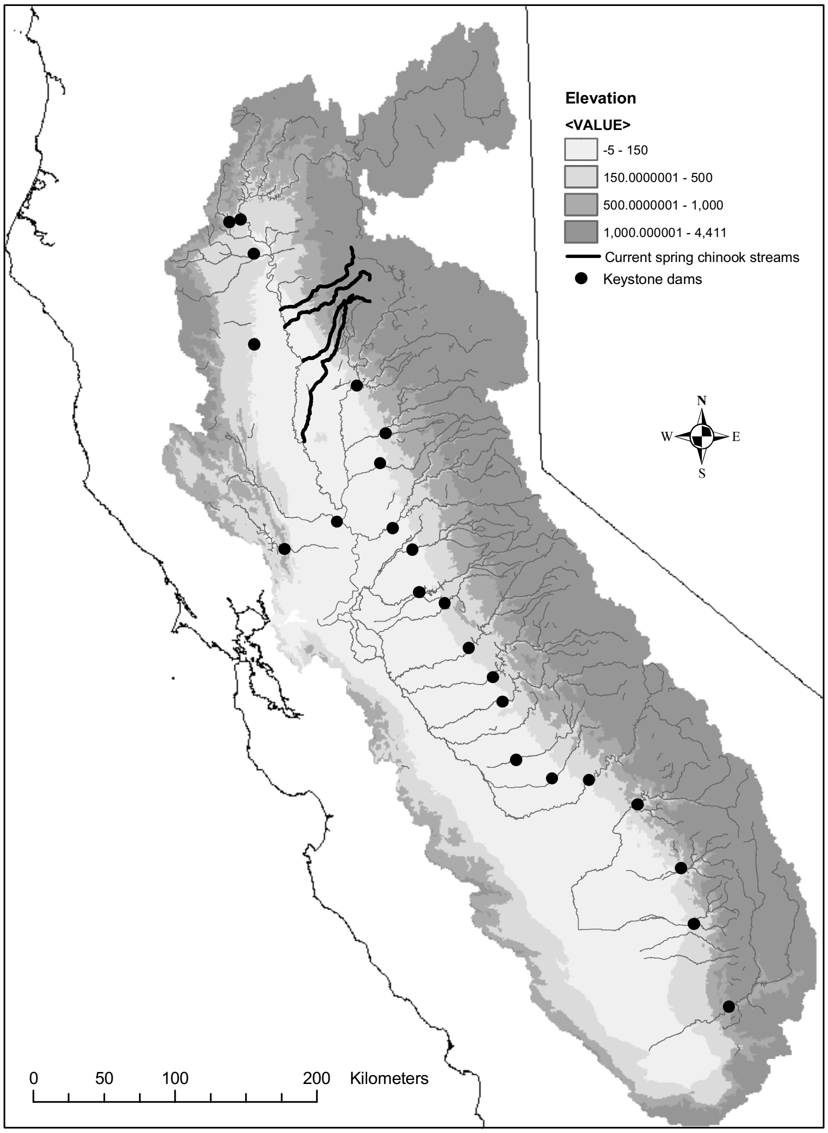

Figure A.2.9.1. Map of Central Valley showing the locations of spring-run chinook salmon populations with consistent runs, plus Big Chico Creek, which in recent years has had a small run. These populations are found in the only watersheds with substantial accessible habitat above 500 m elevation. Keystone dams are the lowest impassable dams on a river or stream.

Previous BRT conclusions

In the original chinook salmon status review, a majority of the BRT concluded that the CV spring-run chinook salmon ESU was in danger of extinction (Myers et al. 1998). Listing of this ESU was deferred, and in the status review update, the BRT majority shifted to the view that this ESU was not in danger of extinction, but was likely to become endangered in the foreseeable future (NMFS 1999). A major reason for this shift was data indicating that a large run of spring-run chinook salmon on Butte Creek in 1998 was naturally produced, rather than strays from FRH.

Listing status

Central Valley spring-run chinook salmon were listed as threatened in 1999. Naturally spawning spring-run chinook salmon in the Feather River were included in the listing, but the Feather River Hatchery stock of spring-run chinook salmon was excluded.

A.2.9.2 New Data and Updated Anlayses

Status assessments

In 1998, CDFG reviewed the status of spring-run chinook salmon in the Sacramento River drainage in response to a petition to list these fish under the California Endangered Species Act (CESA) (CDFG 1998). CDFG concluded that spring-run chinook salmon formed an interbreeding population segment distinct from other chinook salmon runs in the Central Valley. CDFG estimated that peak run sizes might have exceeded 600,000 fish in the 1880s, after substantial habitat degradation had already occurred. They blame the decline of spring-run chinook salmon on the early commercial gillnet fishery, water development that blocked access to headwater areas, and habitat degradation. Current risks to the remaining populations include continued habitat degradation related to water development and use, and the operation of FRH. CDFG recommended that Sacramento River spring-run chinook salmon be listed as threatened under the CESA.

Population structure

There are preliminary results for two studies of spring-run chinook salmon population structure. Two important insights are provided by these data sets. First, CV spring-run chinook salmon do not appear to be monophyletic, yet wild CV spring-run chinook salmon populations from different basins are more closely related to each other than to fall-run chinook salmon from the same basin. Second, neither Feather River natural (FR) or Feather River Hatchery (FRH) spring-run chinook salmon are closely related to any of the three wild populations although they are closely related to each other and to CV fall-run chinook salmon.

David Teel of the NWFSC used allozymes to show that Butte and Deer creek spring-run chinook salmon are not closely related to sympatric fall-run chinook salmon populations or the FRH spring-run chinook salmon stock (Figure A.2.9.2). FRH spring-run chinook salmon, putative Feather River natural spring-run chinook salmon, and Yuba River spring-run chinook salmon fell into a large cluster composed mostly of natural and hatchery fall-run chinook salmon.

Dennis Hedgecock and colleagues, using 12 microsatellite markers, showed that there are two distinct populations of chinook salmon in the Feather River (Hedgecock 2002). One population is formed by early-running ("spring-run") chinook salmon, the other by late running fish ("fall-run"). Once run timing was accounted for, hatchery and naturally spawning fish appear to form a homogeneous population. The Feather River spring-run population is most closely related to FR fall-run (F_{st}=0.010) and to Central Valley fall-run chinook salmon (F_{st}=0.008), and is distinct from spring-run chinook salmon in Deer, Mill (F_{st}=0.016), and Butte (F_{st}=0.034) Creeks. Figure A.2.9.3 shows the neighbor-joining tree with Cavalli-Sforza and Edwards chord distances and unweighted pair-group method arithmetic averaging.

At least two hypotheses could explain the Feather River observations:

1. An ancestral Mill/Deer/Butte-type spring-run chinook salmon was forced to hybridize with the fall-run chinook salmon, producing an intermediate form.
2. The ancestral Feather River spring-run chinook salmon had a common ancestor with the Feather River fall-run chinook salmon, following the pattern seen in Klamath chinook salmon but different from the pattern seen in Deer, Butte, and Mill Creeks. The FR and FRH populations have merged.

Hedgecock argues against the first hypothesis. Feather River fish cluster well within Central Valley fall-run chinook salmon rather than between Mill/Deer/Butte spring-run chinook salmon and Central Valley fall-run chinook salmon, as would be expected under hypothesis 1. Furthermore, there is no evidence from linkage disequilibria that FR spring-run and FR fall-run populations are hybridizing, i.e., these populations are reproductively isolated. It is perhaps not surprising that Feather River spring-run chinook salmon might have a different ancestry than spring-run chinook salmon in Mill, Deer, and Butte Creeks, because the Feather River is in a different ecoregion.

Regardless of the cause of the genetic patterns described above, these new data do not support the current configuration of the CV spring-run chinook salmon ESU. Feather River spring-run chinook salmon do not appear to share a common ancestry or evolutionary trajectory with other spring-run chinook salmon populations in the Central Valley. They share the designation of "spring-run" chinook salmon, and indeed, the Feather River and FRH have a chinook salmon spawning run that starts much earlier than other Sacramento basin rivers. There is no longer a distinct bimodal distribution to run timing, however, and substantial fractions of fish released as FRH spring-run chinook salmon have returned during the fall-run chinook salmon period (and vice versa) (CDFG 1998). If FR and FRH spring-run chinook salmon are retained in the CV spring-run chinook salmon ESU, then the ESU configuration of the CV fall-late-fall-run chinook salmon ESU (among several others) should be reconsidered for the sake of consistency, because late-fall-run chinook salmon are more distinct genetically and arguably as distinct in terms of life history as FRH spring-run chinook salmon.

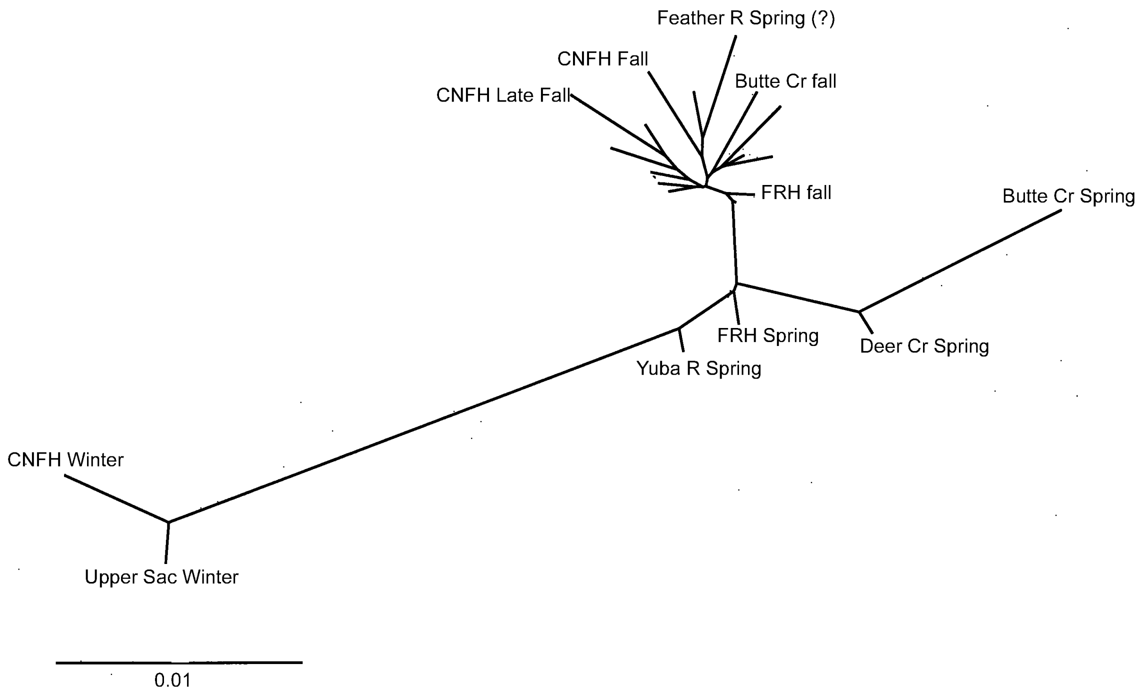

Figure A.2.9.2. Neighbor joining tree (Cavalli-Sforza and Edwards chord distances) for Central Valley chinook salmon populations, based on 24 polymorphic allozyme loci (unpublished data from D. Teel, NWFSC). Populations labeled with only a number are various fall-run chinook salmon populations. The "?" after Feather R Spring indicates that CDFG biologists are not certain that the fish collected for that sample are truly spring-run chinook salmon.

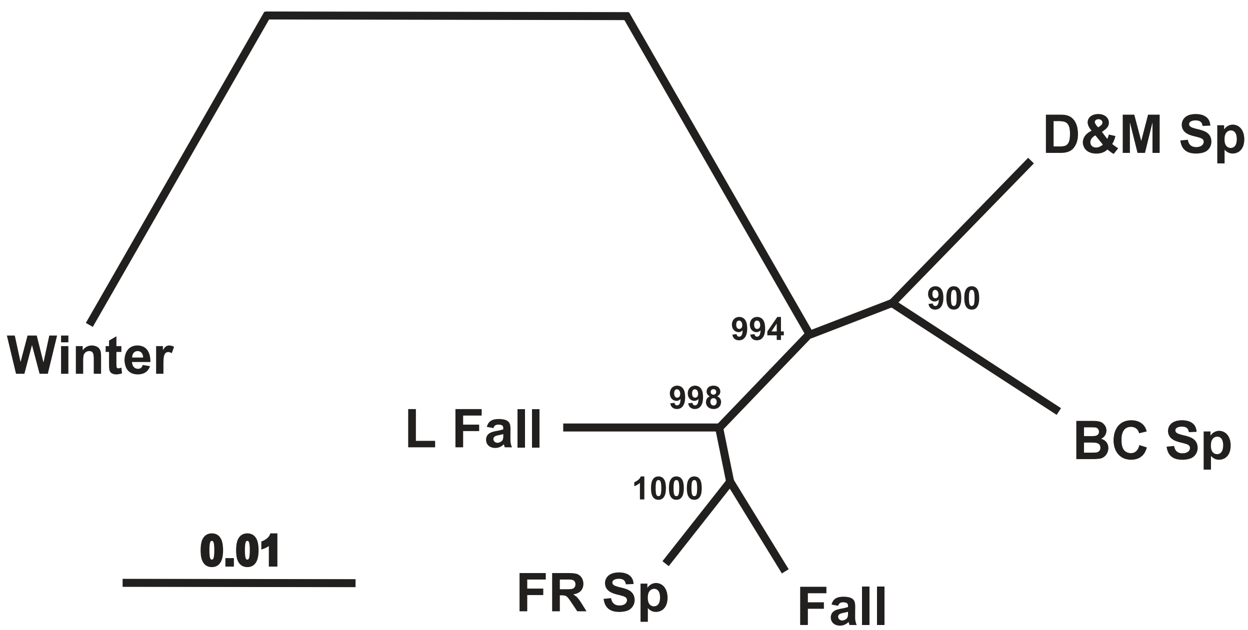

Figure A.2.9.3. Neighbor joining tree (Cavalli-Sforza and Edwards chord distances) for Central Valley chinook salmon populations, based on 12 microsatellite loci. D&M = Deer and Mill Creek; BC = Butte Creek; FR = Feather River; Sp= spring-run chinook salmon; L Fall-run = late-fall-run chinook salmon; Winter = winter-run chinook salmon. The tree was constructed using Cavalli-Sforza and Edwards measure of genetic distance and the unweighted pair-group method arithmetic averaging. Figure from Hedgecock (2002).

Historic habitat loss

Yoshiyama and colleagues detailed the historic distribution of CV spring-run chinook salmon. Yoshiyama et al. (2001) estimated that 72% of salmon spawning and rearing habitat has been lost in the Central Valley. This figure is for fall-run as well as spring-run chinook salmon, so the amount of spring-run chinook salmon habitat lost is presumably higher because spring-run chinook salmon spawn and rear in higher elevations, areas more likely to be behind impassable dams. They deem the 95% loss estimate of CDFG (Reynolds et al. 1993) as "perhaps somewhat high but probably roughly accurate."

Life history

CDFG recently began intensive studies of Butte Creek spring-run chinook salmon (Ward et al. 2002). One of the more interesting observations is that while the great majority of spring-run chinook salmon leave Butte Creek as young-of-the-year, yearling outmigrants make up roughly 25% of the ocean catch of Butte Creek spring-run chinook salmon.

Harvest information

Substantial changes in ocean fisheries off central and northern California have occurred since the last status review (PFMC 2002a, b). Ocean harvest rate of CV spring-run chinook salmon is thought to be a function of the Central Valley chinook salmon ocean harvest index (CVI), which is defined as the ratio of ocean catch south of Point Arena to the sum of this catch and the escapement of chinook salmon to Central Valley streams and hatcheries. Note that other stocks (e.g., Klamath chinook salmon) contribute to the catch south of Point Arena. This harvest index ranged from 0.55 to nearly 0.80 from 1970 to 1995, when harvest regimes were adjusted to protect winter-run chinook salmon. In 2001, the CVI fell to 0.27. The reduction in harvest is presumably at least partly responsible for the record spawning escapement of fall-run chinook salmon ($\approx$ 540,000 fish in 2001) and recent increases in spring-run populations.

Coded-wire tagging of juvenile spring-run chinook salmon in Butte Creek provides some limited information on the ocean distribution of this population; there have not yet been enough tag recoveries for a full cohort reconstruction. Butte Creek spring-run chinook salmon have a more northerly distribution than winter-run chinook salmon (PFMC 2003), with recoveries off of Oregon and in the Klamath Management Zone and Fort Bragg areas. The majority of recoveries have been south of Point Arena.

Abundance data

The time series of abundance for Mill, Deer, Butte, and Big Chico Creek spring-run chinook salmon have been updated through 2001, and show that the increases in population that started in the early 1990s has continued (Figure A.2.9.4). During this period, there have been significant habitat improvements (including the removal of several small dams and increases in summer flows) in these watersheds, as well as reduced ocean fisheries and a favorable terrestrial and marine climate.

The time series for Butte, Deer, and Mill Creeks are barely amenable to simple analysis with the random walk-wth-drift model (Homes 2001, Lindley in press). The data series are short, and inconsistent methods were used until 1992, when a consistent snorkel survey was initiated on Butte and Deer Creeks. The full records for these three systems are analyzed with the knowledge that there may be significant errors in pre-1992 observations. Table A.2.9.1 summarizes the analyses of these time series.

It appears that the three spring-run chinook salmon populations in the Central Valley are growing. The current 5-year geometric means for all three populations are also the maximum 5-year means. All three spring-run chinook salmon populations have long- and short-term $\lambda > 1$ (λ is defined as $\exp(\mu + \sigma^2_p / 2)$—the *mean* annual population growth rate in this document), with lower bounds of 90% confidence intervals generally > 1. Long- and short-term trends are also positive, although some confidence interval lower bounds are negative. CV spring-run chinook salmon have some of the highest population growth rates in the Central Valley, but other than Butte Creek and the hatchery-influenced Feather River, population sizes are relatively small compared to fall-run chinook salmon populations (Figure A.2.9.5).

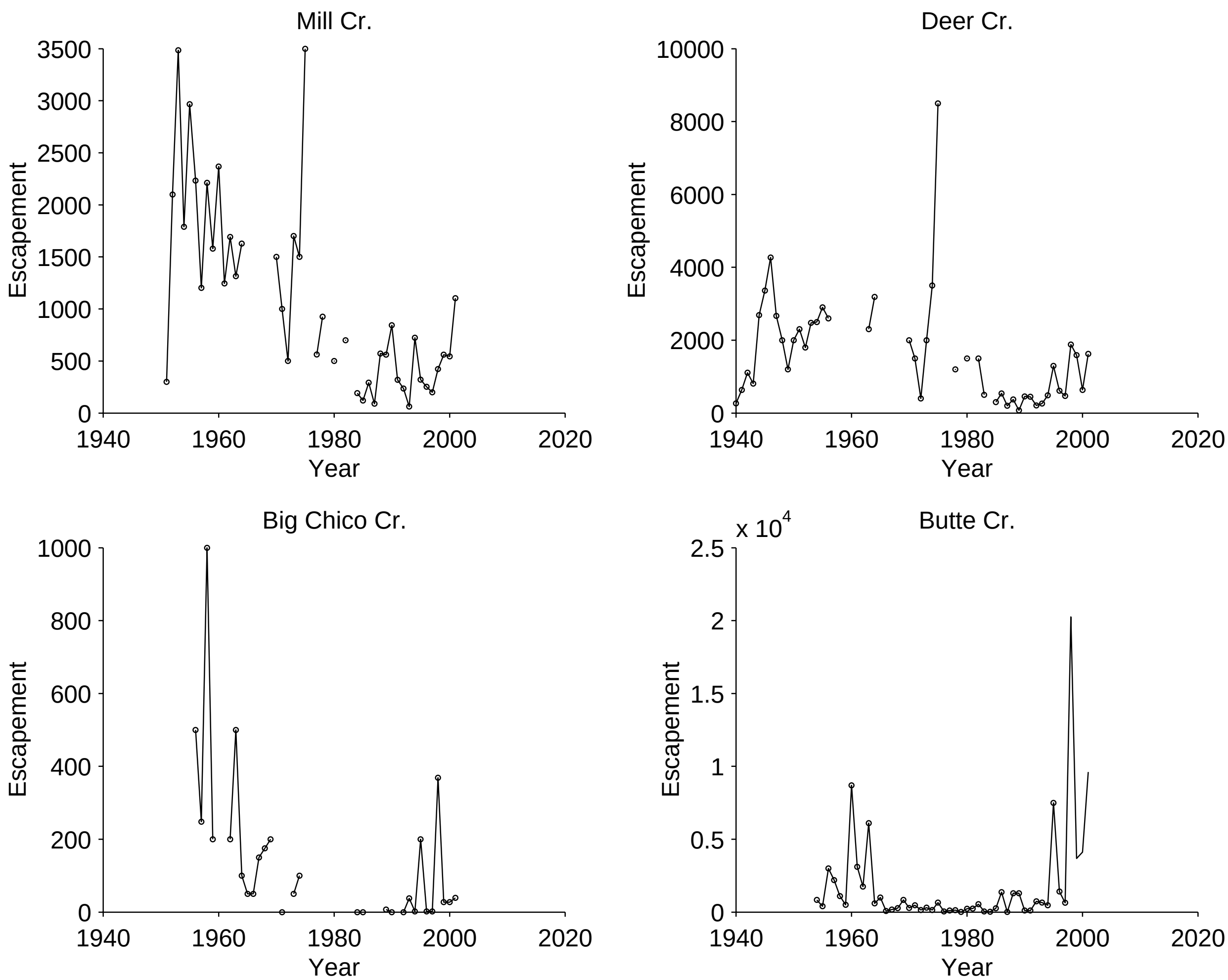

Figure A.2.4. Time series of population abundance for Central Valley spring-run chinook salmon.

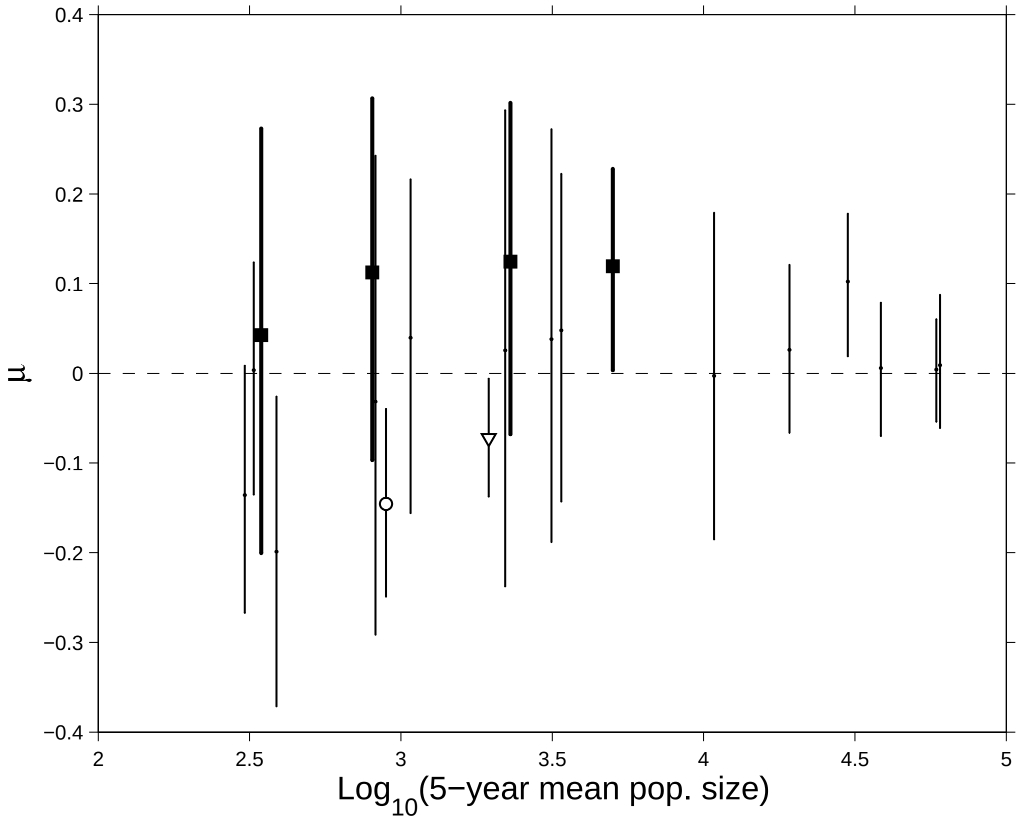

Figure A.2.5. Abundance and growth rate of Central Valley salmonid populations. Open circle- steelhead; filled squares- spring-run chinook salmon; open triangle- winter-run chinook salmon; small black dots- other chinook salmon stocks (mostly fall runs). Error bars represent central 0.90 probability intervals for μ estimates. (Note: as defined in other sections of the status reviews, $\mu \approx \log [\lambda]$.)

Table A.2.9.1. Summary statistics for trend analyses. Numbers in parentheses are 0.90 confidence intervals.

Population	5-yr mean	5-yr min	5-yr max	λ	μ	LT trend	ST trend
Sacramento River winter-run chinook	2,191	364	65,683	0.97 (0.87, 1.09)	-0.10 (-0.21, 0.01)	-0.14 (-0.19, -0.09)	0.26 (0.04, 0.48)
Butte Creek spring-run chinook	4,513	67	4,513	1.30 (1.09, 1.60)	0.11 (-0.05, 0.28)	0.11 (0.03, 0.19)	0.36 (0.03, 0.70)
Deer Creek spring-run chinook	1,076	243	1,076	1.17 (1.04, 1.35)	0.12 (-0.02, 0.25)	0.11 (0.02, 0.21)	0.16 (-0.01, 0.33)
Mill Creek spring-run chinook	491	203	491	1.19 (1.00, 1.47)	0.09 (-0.07, 0.26)	0.06 (-0.04, 0.16)	0.13 (-0.07, 0.34)

New Hatchery Information

FRH currently aims to release 5 million spring-run chinook salmon smolts per year although actual releases have been mostly lower than this goal (Figure A.2.9.6). Returns to the hatchery appear to be directly proportional to the releases (Figure A.2.9.7).

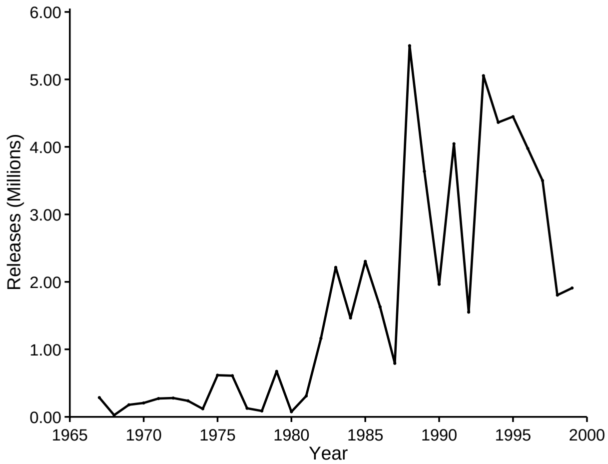

Figure A.2.9.6. Number of spring-run chinook salmon released by Feather River Hatchery.

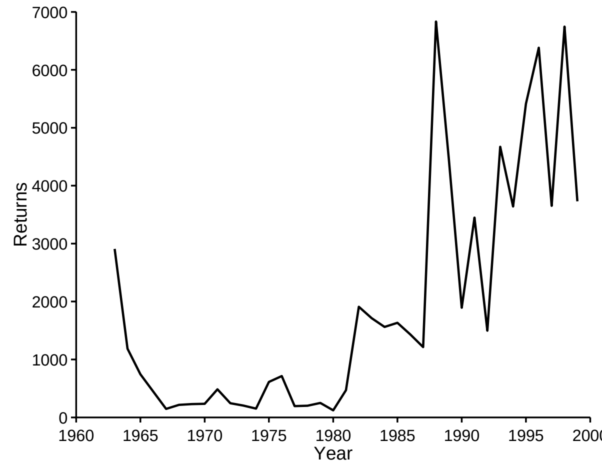

Figure A.2.9.7. Number of spring-run chinook salmon returning to Feather River Hatchery.

New Comments

The State Water Contractors (SWC) submitted several documents, one of them relevant to the status review for CV spring-run chinook salmon. The document, "Reconsideration of the listing status of spring-run chinook salmon within the Feather River portion of the Central Valley ESU," argues that Feather River spring-run chinook salmon should not be included in the CV spring-run chinook salmon ESU and do not otherwise warrant protection under the ESA. SWC also suggested that NMFS conduct a series of evaluations of the following topics:

1. impact of hatchery operations on the population dynamics and the genetic integrity of natural stocks
2. hatcheries as conservation
3. effects of mixed-stock fisheries
4. assessment of the relative roles of different mortality factors
5. experimental assessment of the effects of river operations
6. efficacy of various habitat improvements
7. stock identification for salvage and ocean fishery management
8. constant fractional marking

The California Farm Bureau Federation (CFBF) submitted comments with several attachments calling for the removal of most salmonid ESUs from the endangered species list. The attachments included: 1) an analysis by B.J. Miller showing that significant and expensive changes to water operations in the delta provide fairly modest benefits to chinook salmon populations; 2) "Reconsideration of the listing status of spring-run chinook salmon within the Feather River portion of the Central Valley ESU," discussed in the preceding paragraph; 3) a memo from J.F. Palmisano to C.H. Burley arguing that because changes in marine climate have been shown to influence salmon stocks, other putative causes for declines of salmonid populations must be over-rated. CFBF reviews *Alsea Valley Alliance v. Evans* and argues that hatchery fish must be included in risk analyses.

A.2.9.3 Comparison with Previous Data

The upward trends in abundance of the Mill, Deer, and Butte Creek populations noted in the most recent previous status review (NMFS 1999) have apparently continued, probably due in part to the combined effects of habitat restoration, reduced fishing effort in the ocean, and favorable climatic conditions. New population genetics information confirms previous suspicions that Feather River hatchery and Feather River spring-run chinook salmon are not closely related to the Mill, Deer, and Butte Creek spring-run chinook salmon populations.

A.3 CHINOOK SALMON BRT CONCLUSIONS

Snake River fall-run chinook salmon ESU

A majority (60%) of the BRT votes for this ESU fell in the "likely to become endangered" category, with minorities falling in the "danger of extinction" and "not likely to become endangered" categories (Table A.3.1). This represented a somewhat more optimistic assessment of the status of this ESU than was the case at the time of the original status review, when the BRT concluded that Snake River fall-run chinook salmon "face a substantial risk of extinction if present conditions continue" (Waples et al. 1991). The BRT found moderately high risks in all VSP elements, with mean risk matrix scores ranging from 3.0 for growth rate/productivity to 3.6 for spatial structure (Table A.3.2).

On the positive side, the number of natural origin spawners in 2001 was well in excess of 1000 for the first time since counts at Lower Granite Dam began in 1975. Management actions have reduced (but not eliminated) the fraction of fish passing Lower Granite Dam that are strays from out-of-ESU hatchery programs. Returns in the last two years also reflect an increasing contribution from supplementation programs based on the native Lyons Ferry Broodstock. With the exception of the increase in 2001, the ESU has fluctuated between approximately 500-1000 adults, suggesting a somewhat higher degree of stability in growth rate and trends than is seen in many other salmon populations.

In spite of the recent increases, however, the recent geometric mean number of naturally produced spawners is still less than 1000, a very low number for an entire ESU. Because of the large fraction of naturally spawning hatchery fish, it is difficult to assess the productivity of the natural population. The relatively high risk matrix scores for spatial structure and diversity (3.5-3.6) reflect the concerns of the BRT that a large fraction of historic habitat for this ESU is inaccessible, diversity associated with those populations has been lost, the single remaining population is vulnerable to variable environmental conditions or catastrophes, and continuing immigration from outside the ESU at levels that are higher than occurred historically. Some BRT members were concerned that the efforts to remove stray, out-of-ESU hatchery fish only occur at Lower Granite Dam, well upstream of the geographic boundary of this ESU. Specific concerns are that natural spawners in lower river areas will be heavily affected by strays from Columbia River hatchery programs, and that this approach effectively removes the natural buffer zone between the Snake River ESU and Columbia River ocean-type chinook salmon. The effects of these factors on ESU viability are not known, as the extent of natural spawning in areas below Lower Granite Dam is not well understood, except in the lower Tucannon River.

Snake River spring/summer-run chinook salmon ESU

About two-thirds (68%) of the BRT votes for this ESU fell in the "likely to become endangered" category, with minorities falling in the "danger of extinction" and "not likely to become endangered" categories (Table A.3.1). As indicated by mean risk matrix scores, the BRT had much higher concerns about abundance (3.6) and growth rate/productivity (3.5) than for spatial structure (2.2) and diversity (2.3) (Table A.3.2).

Although there are concerns about loss of an unquantified number of spawning aggregations that historically may have provided connectivity between headwater populations, natural spawning in this ESU still occurs in a wide range of locations and habitat types.

Like many others, this ESU saw a large increase in escapement in many (but not all) populations in 2001. The BRT considered this an encouraging sign, particularly given the record low returns seen in many of these populations in the mid 1990s. However, recent abundance in this ESU is still short of the levels that the proposed recovery plan for Snake River salmon indicated should be met over at least an eight year period (NMFS 1995). The BRT considered it a positive sign that the non-native Rapid River broodstock has been phased out of the Grande Ronde system, but the relatively high level of both production/mitigation and supplementation hatcheries in this ESU leads to ongoing risks to natural populations and makes it difficult to assess trends in natural productivity and growth rate.

Upper Columbia River spring-run chinook salmon ESU

Assessments by the BRT of the overall risks faced by this ESU were divided, with a slight majority (53%) of the votes being cast in the "danger of extinction" category and a substantial minority (45%) in the "likely to be endangered" category (Table A.3.1). The mean risk matrix scores reflect strong ongoing concerns regarding abundance (4.4) and growth rate/productivity (4.5) in this ESU and somewhat less (but still significant) concerns for spatial structure (2.9) and diversity (3.5) (Table A.3.2).

Many populations in this ESU have rebounded somewhat from the critically low levels that immediately preceded the last status review evaluation, and this was reflected in the substantial minority of BRT votes cast that were not cast in the "danger of extinction" category. Although this was considered an encouraging sign by the BRT, the last year or two of higher returns come on the heels of a decade or more of steep declines to all time record low escapements. In addition, this ESU continues to have a very large influence by hatchery production, both from production/mitigation and supplementation programs. The extreme management measures taken in an effort to maintain populations in this ESU during some years in the late 1990s (collecting all adults from major basins at downstream dams) are a strong indication of the ongoing risks to this ESU, although the associated hatchery programs may ultimately play a role in helping to restore self-sustaining natural populations.

Lower Columbia River chinook salmon ESU

A majority (71%) of the BRT votes for this ESU fell in the "likely to become endangered" category, with minorities falling in the "danger of extinction" and "not likely to become endangered" categories (Table A.3.1). Moderately high concerns for all VSP elements are indicated by mean risk matrix scores ranging from 3.2 for abundance to 3.9 for diversity (Table A.3.2).

All of the risk factors identified in previous reviews were still considered important by the BRT. The Willamette/Lower Columbia River TRT has estimated that 8-10 historic populations in this ESU have been extirpated, most of them spring-run populations. Near loss of that important life history type remains in important BRT concern. Although some natural production currently occurs in 20 or so populations, only one exceeds 1000 spawners. High hatchery production continues to pose genetic and ecological risks to natural populations and to mask their performance. Most populations in this ESU have not seen as pronounced increases in recent years as occurred in many other geographic areas.

Upper Willamette River chinook salmon ESU

A majority (70%) of the BRT votes for this ESU fell in the “likely to become endangered” category, with minorities falling in the “danger of extinction” and “not likely to become endangered” categories (Table A.3.1). The BRT found moderately high risks in all VSP elements (mean risk matrix scores ranged from 3.1 for growth rate/productivity to 3.6 for spatial structure) (Table A.3.2).

Although the number of adult spring-run chinook salmon crossing Willamette Falls is in the same range (about 20,000–70,000) it has been for the last 50 years, a large fraction of these are hatchery produced. The score for spatial structure reflects concern by the BRT that perhaps a third of the historic habitat used by fish in this ESU is currently inaccessible behind dams, and the BRT remained concerned that natural production in this ESU is restricted to a very few areas. Increases in the last 3-4 years in natural production in the largest remaining population (the McKenzie) were considered encouraging by the BRT. With the relatively large incidence of hatchery fish, it is difficult to determine trends in natural production.

Puget Sound chinook salmon ESU

A majority (74%) of the BRT votes for this ESU fell in the “likely to become endangered” category, with minorities falling in the “danger of extinction” and “not likely to become endangered” categories (Table A.3.1). The BRT found moderately high risks in all VSP elements, with mean risk matrix scores ranging from 2.9 for spatial structure to 3.6 for growth rate/productivity (Table A.3.2).

Most population indices for this ESU have not changed substantially since the last BRT assessment. The Puget Sound TRT has identified approximately 31 historic populations, of which 9 are believed to be extinct, with most of the populations that have been lost being early run. Other concerns noted by the BRT are the concentration of the majority of natural production in just two basins, high levels of hatchery production in many areas of the ESU, and widespread loss of estuary and lower floodplain habitat diversity (and, likely, associated life history types). Although populations in this ESU have not experienced the sharp increases in the last 2-3 years seen in many other ESUs, more populations increased than decreased over the 4 years since the last BRT assessment. After adjusting for changes in harvest rates, however, trends in productivity are less favorable. Most populations are relatively small, and recent natural production within the ESU is only a fraction of estimated historic run size. On the positive side, harvest rates for all populations have been reduced from their peaks in the 1980s, and some hatchery reforms have been implemented (e.g., elimination of many net pen programs that were leading to widespread straying, and transition of other programs to more local broodstocks). The BRT felt that these management changes should help facilitate recovery if other limiting factors (especially habitat degradation) are also addressed. The BRT felt that the large recovery effort organized around the Puget Sound Shared Strategy was a positive step because it could help to link and coordinate efforts in many separate, local watersheds.

California Coastal chinook salmon ESU

A majority (67%) of the BRT votes for this ESU fell in the "likely to become endangered" category, with votes falling in the "danger of extinction" category outnumbering those in "not warranted" category by nearly 2-to-1 (Table A.3.1). The BRT found moderately high risks in all VSP elements, with mean risk matrix scores ranging from 3.1 for diversity to 3.9 for abundance (Table A.3.2).

The BRT was concerned by continued evidence of low population sizes relative to historical abundance and mixed trends in the few time series of abundance indices available for analysis, and by the low abundances and potential extirpations of populations in the southern part of the ESU. The BRT's concerns regarding genetic integrity of this ESU were moderate or low relative to similar issues for other ESUs because 1) hatchery production in this ESU is on a minor scale, and 2) current hatchery programs are largely focused on supplementing and restoring local populations. However, the BRT did have concerns with respect to diversity that were based largely on the loss of spring-run chinook salmon in the Eel River basin and elsewhere in the ESU, and to a lesser degree on the potential loss of diversity concurrent with low abundance or extirpation of populations in the southern portion of the ESU. Overall, the BRT was strongly concerned by the paucity of information and resultant uncertainty associated with estimates of abundance, natural productivity and distribution of chinook salmon in this ESU.

Sacramento River winter-run chinook salmon ESU

A majority (60%) of the BRT votes fell into the "in danger of extinction" category, with a minority (38%) voting for the "likely to become endangered" and only 2% voting for "not warranted." (Table A.3.1). The main VSP concerns were in the spatial structure and diversity categories (4.8 and 4.2, respectively), although there was significant concern in the abundance and productivity categories (3.7 and 3.5, respectively) (Table A.3.2).

The main concerns of the BRT relate to the lack of diversity within this ESU. The BRT was very troubled by the fact that this ESU is represented by a single population that has been displaced from its historic spawning habitat into an artificial habitat created and maintained by a dam. The BRT presumed that several independent populations of winter-run chinook salmon were merged into a single population, with the potential for a significant loss of life history and genetic diversity. Furthermore, the population has passed through at least two recent bottlenecks—one when Shasta Dam was filled and another in the late 1980s-early 1990s—that probably further reduced genetic diversity. The population has been removed from the environment where it evolved, dimming its long-term prospects for survival. The BRT was modestly heartened by the increase in abundance since the lows of the late 1980s and early 1990s.

Central Valley spring-run chinook salmon ESU

A large majority (69%) of the BRT votes fell into the “likely to become endangered” category, with a minority (27%) of votes going to “in danger of extinction” and 4% “not warranted” (Table A.3.1). There was roughly equal concern about abundance, spatial structure and diversity (3.5-3.8), and less concern about productivity (2.8) (Table A.3.2).

A major concern of the BRT was the loss of diversity caused by the extirpation of spring-run chinook salmon populations from most of the Central Valley, including all San Joaquin tributaries. The only populations left in the Sierra Nevada ecoregion are supported by the Feather River hatchery. Another major concern of the BRT was the small number and location of extant spring-run chinook salmon populations-- only three streams, originating in the southern Cascades, support self-sustaining runs of spring-run chinook salmon, and these three streams are close together, increasing their vulnerability to catastrophe. Two of the three extant populations are fairly small, and all were recently quite small. The BRT was also concerned about the Feather River spring-run chinook salmon hatchery population, which is not in the ESU but does produce fish that potentially could interact with other spring-run chinook salmon populations, especially given the off-site release of the production.

Table A.3.1. Tally of FEMAT vote distribution regarding the status of 9 chinook salmon ESUs reviewed by the chinook salmon BRT. Each of 15 BRT members allocated 10 points among the three status categories.

ESU	At Risk of Extinction	Likely to Become Endangered	Not Likely to Become Endangered
Snake River fall-run	38	91	21
Snake River spring/summer-run	30	102	18
Upper Columbia River spring-run	79	67	4
Puget Sound	12	111	27
Lower Columbia River	25	107	18
Upper Willamette River	32	105	13
California Coastal[1]	36	100	13
Sacramento River winter-run[2]	78	49	3
CA Central Valley spring-run[2]	35	90	5

[1] One BRT member assigned 9 points [2] Votes tallied for 13 BRT members

Table A.3.2. Summary of risk scores (1 = low to 5 = high) for four VSP categories (see section "Factors Considered in Status Assessments" for a description of the risk categories) for the 9 chinook salmon ESUs reviewed. Data presented are means (range).

ESU	Abundance	Growth Rate/Productivity	Spatial Structure and Connectivity	Diversity
Snake River fall-run	3.4 (2-5)	3.0 (2-5)	3.6 (2-5)	3.5 (2-5)
Snake River spring/summer-run	3.6 (2-5)	3.5 (3-5)	2.2 (1-3)	2.3 (1-3)
Upper Columbia River spring-run	4.4 (3-5)	4.5 (3-5)	2.9 (2-4)	3.5 (2-5)
Puget Sound	3.3 (2-4)	3.6 (3-4)	2.9 (2-4)	3.2 (2-4)
Lower Columbia River	3.2 (2-4)	3.7 (3-5)	3.5 (3-4)	3.9 (3-5)
Upper Willamette River	3.7 (2-5)	3.1 (2-5)	3.6 (3-4)	3.2 (2-4)
California Coastal[1]	3.9 (3-5)	3.3 (3-4)	3.2 (2-4)	3.1 (2-4)
Sacramento River winter-run[2]	3.7 (3-5)	3.5 (2-5)	4.8 (4-5)	4.2 (3-5)
CA Central Valley spring-run[2]	3.5 (3-4)	2.8 (2-4)	3.8 (3-5)	3.8 (3-5)

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